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ABSTRACT

This study was designed to assess the effectiveness, with respect to science process skill development, of the elementary science curriculum designed by the Science Curriculum Improvement Study (SCIS). The assessment was made by statistically comparing the scores on "The Science Process Instrument" of two groups of students. The experimental group had only the SCIS program in learning science; the second group, the control group, used only the textbook approach to learning science. Data clearly indicated the superiority of the SCIS curriculum over the textbook curriculum for developing the student's ability to utilize science processes. (Author/CP)

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M. C. Weber
Southwestern State College
Weatherford, Oklahoma 73096

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CHAPTER I

INTRODUCTORY SECTION

Summary

The problem to which this study was directed was to assess the effectiveness of the Science Curriculum Improvement Study (SCIS) curriculum in developing the learner's ability to utilize selected science processes. The assessment was made by comparing the scores made on the Science Process Instrument by two groups of fifth grade children. One group, the experimental group, had experienced only the SCIS curriculum since entering school, while the second group, the control group, had experienced only a textbook approach to science learning.

Because of the ex post facto nature of the research, the students in the two groups were matched on the variables of sex, age, intelligence level, and socio-economic status. Additionally, the students came from schools that had similar organizational structures and similar curricula, except for the science programs.

The hypotheses of the study were based on the science processes of observation, classification, measurement, experimentation, interpretation, and prediction. The Science Process Instrument was designed to measure the students' performance levels on tasks involving these processes. Specifically, the following null hypotheses were formulated for guiding the direction of the research. They were tested at the 0.10 level for significance.

H_1 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to utilize science processes.

H_2 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to observe.

H_3 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to classify.

H_4 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to measure.

H_5 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to experiment.

H_6 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to interpret.

H_7 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to predict.

The student scores were treated with the Wilcoxon matched pairs signed ranks statistical test. The statistical treatment indicated that each of the null hypotheses should be rejected in favor of the SCIS curriculum. The level of significance for each respective hypothesis was as follows: $H_1 = 0.000002$; $H_2 = 0.000072$; $H_3 = 0.0007$; $H_4 = 0.0007$; $H_5 = 0.000013$; $H_6 = p\ 0.05$; $H_7 = 0.0002$.

The rejection of these null hypotheses in favor of the SCIS curriculum clearly indicates its superiority in developing the science processes of observation, classification, measurement, experimentation, interpretation, and prediction. The investigator believes the findings of this investigation warrant the acceptance of the SCIS program as being a curriculum which does develop the learner's ability to utilize science processes.

Introduction

Background of Study

The Science Curriculum Improvement Study (SCIS) is a curriculum reform project which originated in 1959 in Berkeley, California, supported by a grant from the National Science Foundation.(1) The intent of this project was to develop an elementary science curriculum which emphasized an investigatory approach to learning science. Contemporary literature began describing this type of science learning as inquiry-discovery centered.

The SCIS project established the long range goal of developing scientific literacy within the learner. By definition, SCIS described scientific literacy as being a blend of knowledge, process skills, and attitudes.(2)

To attain this goal, the children are introduced to scientific content through diverse investigations involving physical and biological materials, and in the course of their investigations, they are engaged in observation, measurement, interpretation, prediction, and other processes.(3) Thus, the SCIS curriculum can be described as having a conceptual framework which is bound together by science processes.

Logically, then, an assessment of the effectiveness of the SCIS curriculum could be approached through its influence on the development of the learner's operational utilization of selected science processes. This was the premise on which this investigation was based.

Need for the Study

The SCIS curriculum has been widely adopted in schools across the United States even though there are few research data with respect to its effectiveness as a science curriculum. This study would provide data which would permit a partial evaluation of the curriculum.

Another factor which pointed to the need for this study was the four million dollars in public moneys which the project had received since its inception.(4) Public moneys were being spent with little evaluative knowledge.

These two combined factors presented a pressing need for data on which an evaluation could be made. That was the impetus behind this study.

Statement of the Problem

The problem to which this study was directed was to assess the effectiveness of the SCIS curriculum in developing the learner's ability to utilize selected science processes. The processes selected for this assessment were observation, classification, measurement, interpretation, experimentation, interpretation, and prediction.

The Hypotheses

Seven null hypotheses were formulated for providing the direction of this study. These hypotheses are as follows:

H_1 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to utilize science processes.

H_2 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to observe.

H_3 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to classify.

H_4 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to measure.

H_5 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to experiment.

H_6 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to interpret.

H_7 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to predict.

These null hypotheses were tested at the 0.10 level of significance. This level was selected in order to reduce the probability of making a Type II Error. Type II Errors result when false null hypotheses are accepted, whereas Type I Errors result when true null hypotheses are rejected.(5) In this study, a Type II Error would have meant the null hypothesis would have been accepted when in fact it would not have been true. Consequently, schools would be reluctant to attempt such a science curriculum. A Type I Error would have meant that schools would spend money although the method would not have been any more efficient for learning science.

Limitations of Research

This study had three inherent limitations. These should be carefully considered by the reader in interpreting the results of the research. The limitations are delineated below.

(1) The research procedures of this study were such that the investigation was representative of ex post facto research. Kerlinger (6) identifies ex post facto research by the fact that the independent variable has occurred before the research begins. Thus, the researcher studies the possible relation or the effect of the independent variable on the dependent variable.

(2) The investigator selected the science processes of observation, classification, measurement, experimentation, interpretation, and prediction as being representative of scientific processes and the processes utilized in the SCIS program. This study was based on the assessment of the performance levels of those processes.

(3) Subject selection was limited by the very nature of the research. The SCIS group consisted of forty-six subjects. This number was significant, however, in that it represented the largest group of students who had studied SCIS science for the longest period in the entire state of Oklahoma.

Research Methods

Overview

This study assessed the effectiveness of the SCIS curriculum in developing the learner's ability to operationally utilize science processes. The assessment was made by comparing the scores obtained on The Science Process Instrument(7) by two groups of students; one group had studied science by the SCIS curriculum while the second group had studied science through a textbook approach.

The Instrument

The instrument used to assess the science process performance levels of the students was developed by the investigator prior to the establishment of this research project. This instrument, The Science Process Instrument, has a split-half reliability coefficient of 0.64. The instrument had a minimum content validity of 0.0082 and a discriminatory power of 0.43.

The instrument consists of 34 tasks designed to measure the student's performance in observation, classification, measurement, experimentation, interpretation, and prediction. According to the criteria of each task, the student was assigned either the numeral 1 or 0, depending on whether the performance of the task was acceptable or not acceptable. The numeral 1 was assigned if the performance was acceptable. The sum of these acceptable responses constituted the raw score which the student received on completing the tasks.

Selection of Subjects

The design of this investigation provided that two groups of students were selected; one group had studied only SCIS science while the second group had a non-SCIS approach to learning science, a textbook approach. An obvious benefit to this study would have been to select students who had been in a particular science program for a long enough period of time to allow that program to make a definite impact on them.

The SCIS group, designated as the experimental group, consisted of 46 fifth grade students. They had studied science through the SCIS curriculum since their first year of school. Those students had studied SCIS science longer than any other group of students in the state of Oklahoma.

The second group, the control group, consisted of 69 fifth grade students who had been in a conventional science textbook-centered curriculum. They too had been in this type of science curriculum since their first year of school.

Comparability of Groups

The validity of this study was directly dependent on how closely the two groups were alike, except for how they had learned science. The two groups were comparable in learning readiness, school and curricular organization, and teacher variability. Individuals in the groups were matched on the factors of sex, chronological age, intelligence level, and socio-economic status. These data are discussed below.

The students in the study had scores from the Metropolitan Readiness Tests(8) recorded when they had entered the first year of school. A chi-square computation on these scores produced a significance level of $p > 0.20$. In other words, there was no significant difference between the two groups in their readiness to learn upon entering the first year of school.

Students in both groups experienced almost identical school organization and curricular programs except for science. The experimental group learned through the SCIS curriculum while the control group learned through textbook science.

The teachers of the two groups had dissimilar pedagogical philosophies. Those of the SCIS group had had formal preparation in methods of inquiry while those in the textbook group had never received this type of preparation. Thus, the two curriculum programs were taught through these respective philosophies.

The forty-six SCIS students and the sixty-nine textbook students were compared and matched on the factors of sex, I.Q., chronological age, and socio-economic level. This comparison yielded thirty pairs of students who were comparable on those factors.

These thirty matched pairs consisted of eighteen females and twelve males. The mean I.Q. for both groups as determined by the California Short Form Test of Mental Maturity(9) was 119. The mean age of the SCIS group was 128 months and 129 months for the control group. The socio-economic ratio for both groups was 28 middle class students and two upper class students as determined by the methods of Warner(10).

Method of Analyzing the Data

The raw data used in the analyses of this study consisted of scores obtained on The Science Process Instrument. Those scores represented the number of acceptable responses made by the subject. In this manner, seven scores were obtained for each subject; i.e., one for the total instrument and one each in observation, classification, measurement, experimentation, interpretation, and prediction.

The raw scores were compiled so that differential comparisons could be made between each matched pair in the seven scoring areas just identified.

These score differences were statistically analyzed through the application of the Wilcoxon matched-pairs signed ranks test(11).

The method for using the Wilcoxon test is as follows. The difference between the scores of each matched pair is ascertained and then ranked without regard to sign with the smallest numerical difference receiving the rank of one; after ranking, the signs of the differences are assigned to the ranks; the ranks are then totaled and the sum with the less frequent sign is used in the test; this smaller sum is referred to as T. A difference of zero was not used in the computations.

The following formula was used in the cases where the sample sizes were larger than twenty-five.

$$Z = \frac{T - \frac{N(N+1)}{4}}{\sqrt{\frac{N(N+1)(2N+1)}{24}}}$$, where

T represents the rank total with the less frequent sign and N is the sample size. Z is the standard score which was used to determine the probability level.

The probability for samples of 25 or less is determined directly from statistical tables. Although, the original sample size was 30 pairs, this size was decreased by the number of no differences between the matched pairs.

CHAPTER II

RESEARCH FINDINGS

The Analysis

The raw data in this study consisted of scores made by the subjects on The Science Process Instrument. Score differences between the matched individuals in the two groups were determined. These differences were treated with the Wilcoxon matched-pairs signed ranks statistical test in order to test each null hypothesis at the 0.10 level of significance.

Analysis of the Total Test Responses

H_1 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to utilize science processes.

In this category 1020 acceptable responses were possible on the total process instrument. The SCIS group scored 689 while the textbook group scored 417. These data yielded results which were signficant at the 0.00002 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Observation Responses

H_2 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to observe.

In this category, 180 acceptable responses were possible on the process instrument. The SCIS group scored 114 while the textbook group scored 63. These data yielded results which were significant at the 0.000072 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Classification Responses

H_3 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to classify.

In this category, 120 acceptable responses were possible on the process

instrument. The SCIS group scored 103 while the textbook group scored 71. These data yielded results which were significant at the 0.0007 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Measurement Responses

H_4 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to measure.

In this category, 180 acceptable responses were possible on the process instrument. The SCIS group scored 104 while the textbook group scored 52. These data yielded results which were significant at the 0.0007 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Experimentation Responses

H_5 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to experiment.

In this category, 180 acceptable responses were possible on the process instrument. The SCIS group scored 124 while the textbook group scored 53. These data yielded results which were significant at the 0.000013 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Interpretation Responses

H_6 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to interpret.

In this category, 180 acceptable responses were possible on the process instrument. The SCIS group scored 113 while the textbook group scored 97. These data yielded results which were significant at the $p < 0.05$ level. The null hypothesis was rejected in favor of the SCIS curriculum.

Analysis of the Prediction Responses

H_7 = No significant difference exists between the SCIS curriculum and the conventional textbook curriculum in developing the student's ability to predict.

In this category, 180 acceptable responses were possible on the process instrument. The SCIS group scored 131 while the textbook group scored 79.

These data yielded results which were significant at the 0.0002 level. The null hypothesis was rejected in favor of the SCIS curriculum.

Discussion of the Data

The seven null hypotheses in this study were rejected in favor of the SCIS curriculum. The SCIS curriculum does significantly develop the student's ability to utilize science processes.

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study was designed to assess the effectiveness, with respect to science process development, of the elementary science curriculum designed by the Science Curriculum Improvement Study (SCIS). The assessment was made by statistically comparing the scores made on The Science Process Instrument (7) by two groups of students. One of these groups, the experimental group, had had only the SCIS program in learning science; the second group, the control group, had had only the textbook approach to learning science. The research data clearly indicated the superiority of the SCIS curriculum over the textbook curriculum for developing the student's ability to utilize science processes.

Recommendations

The following recommendations are based on the results of the study and the investigator's observations and involvement during the investigation.

1. The results of this study clearly indicate the SCIS curriculum is superior to the textbook-centered approach in developing the student's ability to observe, classify, measure, experiment, interpret, and predict. Because these are the same processes on which science activity is based, the SCIS curriculum can be recommended as a program which can be utilized in teaching the structure of science.

2. The investigator observed in the SCIS students certain behaviors which do not appear in the data of this study. The SCIS students appeared to be more diverse, persistent, inventive, and creative in their designs toward performing the necessary operations required of each task on The Science Process Instrument. Future research efforts should be directed toward clarifying these observations with respect to the value of the SCIS curriculum.

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